October 1971 Brief 71-10385

NASA TECH BRIEF

Marshall Space Flight Center

Superconductor Transition Temperatures Study

Intermetallic superconducting compounds crystallizing in the beta-tungsten structure have been investigated in an effort to optimize their superconductive properties. Detailed phase-diagram data have revealed that compounds having the beta-tungsten structure exist as solid solutions over a composition range of several percent. However, for most of these compounds, the relationship between composition and the superconducting transition temperature (T_c) is not known.

In this investigation, several binary alloy systems (V-Si, Nb-Al, Nb-Au, Nb-Ge, Nb-Sn, Nb-Pt, and Ta-Ge) of the beta tungsten structure were synthesized over a range of compositions by an rf-sputtering technique, and T_c was measured at close composition intervals. The rf-sputtering arrangement included two half-disks, each composed of the desired constituent element and placed side by side on a metal electrode connected to an rf power supply. The substrates, made of dense alumina plates, were cooled to 77 K and positioned horizontally above the disks at right angles to their interface so as to obtain maximum composition range. Through a 2 mm wide mask along the entire substrate length, films ranging from 0.3 μm to 1.0 μm (3,000 to 10,000 Å) were sputtered at a pressure of 0.66 N/m^2 (5×10^{-3} torr) in argon. The films were then annealed in quartz tubes dynamically evacuated to 1.33 $\mu N/m^2$ (1×10^{-8} torr) by an ion pump. After the annealing, 50 regularly spaced gold contacts were evaporated across the sample film. DC resistance and T_c measurements were then made for the entire specimen at compositional intervals of approximately 1.5%.

The chemical analysis was based on X-ray fluorescence measurements. Its absolute accuracy was estimated to be approximately 5 atomic percent, whereas the accuracy of the compositional variation for adjacent samples was estimated to be a few tenths of a percent. Structural analysis by X-ray diffraction techniques was possible for only the thickest films (1.0 μm).

The compositional ranges of the binary sputtered films were as much as 70 atomic percent, and each case included the composition range at which the beta-tungsten structure would be expected to exist. The T_c and resistivity data were plotted as a function of composition for each system except Nb-Au. The smooth variation observed in the resistivity ratio (ratio of resistivities at room temperature and at a temperature just above T_c) reflects the uniform background conditions in a given run, as well as a smooth and continuous compositional variation. In several instances, pronounced maxima in the resistivity ratio, accompanied by narrow transition widths, are indicative of compound formation and possibly of an approach to a single phase. Transition temperatures were the same as, or within about 1 degree Kelvin of, the highest T_c reported for bulk materials, even though the sputtered films ranged in thickness.

The sputtering technique proved capable of yielding metastable as well as stable compositions. Preparing the entire range of compositions in one run has the advantage of eliminating specimen property changes as a result of random environmental changes.

(continued overleaf)

Notes:

1. The results of this investigation establish the validity of the rf-sputtering approach and justify continuing the T_c optimization efforts; i.e., temperature-time annealing studies, followed by detailed structural determinations.
2. The following documentation may be obtained from:

   National Technical Information Service
   Springfield, Virginia 22151
   Single document price $3.00
   (or microfiche $0.95)

Reference:
NASA-CR-110432 (N71-30793), Study of Transition Temperatures in Superconductors.

Patent status:

No patent action is contemplated by NASA.

Source: J. J. Hanak, J. T. Gittleman, S. Bozowski, and J. P. Pellicane of
RCA Corp.
under contract to
Marshall Space Flight Center
(MFS-21247)